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Rommel, Simon; Vegas Olmos, Juan José; Tafur Monroy, Idelfonso

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mm-Wave Hybrid Photonic Wireless Links for Ultra-High Speed Wireless Transmissions

Simon Rommel, J. J. Vegas Olmos, Idelfonso Tafur Monroy

Department of Photonics Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

sirem@fotonik.dtu.dk

Introduction & Motivation

Hybrid *photonic-wireless transmission* schemes in the mm-wave frequency range are promising candidates to enable the *multi-gigabit per second data communications* required from *wireless and mobile networks* of the 5th and future generations. Large FCC *spectrum allocations* for wireless transmission at 71–76GHz and 81–86GHz allow high-bandwidth, *long and medium distance* point-to-point links.

Photonic integration may pave the way to practical applicability of such hybrid links by *reduction* in complexity, size and – most important – *cost*.

Silicon Photonic Integrated Circuits

Motivation

Silicon-on-insulator (SOI) photonic integrated circuits (PICs) are a prime candidate for photonic integration, due to a number of factors:

- Compatible to CMOS technology and fabrication infrastructure
 - Highly accurate, high-yield and mature technology
 - Hybrid photonic and electronic integration
- Operation in the 1.3 μ m and 1.55 μ m telecommunications windows
- Large selection of photonic components available
 - Filters
 - Modulators
 - (De-)Multiplexers
 - Mach-Zehnder
 - Splitters
 - Photodetectors
- Active components with heterogeneous integration (III/V, InP etc)

Integration of mm-Wave Transmitter

Silicon photonic integrated circuits allow integration of the mm-wave generation setup, including generation of a wavelength comb or two appropriately spaced spectral lines and the modulation for data transmission or sensing.

mm-Wave Hybrid Photonic Wireless Setup

- (I) Optical Line Termination
- SFP+ for signal generation
 - PRBS15 NRZ from PPG
- Fiber Transmission:
10km SMF & 5km BIF

- (II) Radio Access Unit
- Free running LO
 - Controlled power on PD
 - 8dB RF Amplifier
 - 48dBi Antenna Gain

- (III) Wireless Receiver
- 40dB Low-Noise Amplifier
 - Schottky Diode based Envelope Detector
 - Signal Recovery and Analysis

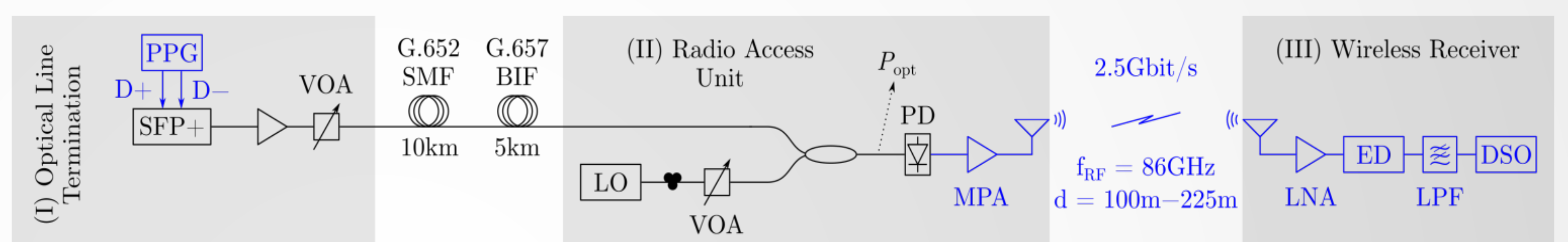


Figure 1. Experimental setup for radio-over-fiber transmission. SFP+: enhanced small form-factor pluggable, PPG: pulse pattern generator, VOA: variable optical attenuator, LO: local oscillator, PD: photodiode, MPA: medium power amplifier, LNA: low noise amplifier, ED: envelope detector, LPF: Lowpass filter, DSO: digital storage oscilloscope

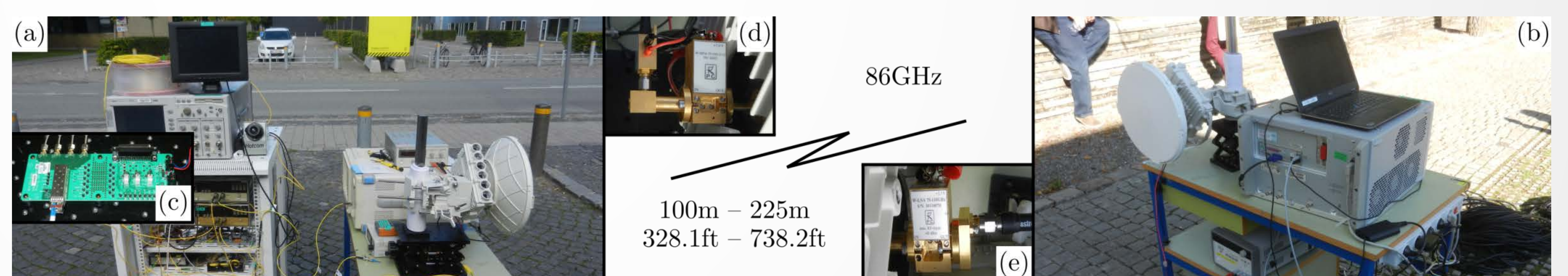


Figure 2. Outdoor experimental setup: (a) transmitter station, (b) receiver station, (c) evaluation board with SFP+, (d) PD and MPA mounted on transmit antenna, (e) LNA and ED mounted on receive antenna

millimeter Wave Silicon Photonics for Remote Sensing and Wireless Links

mmW-SPRAWL

AARHUS UNIVERSITY

Martijn Heck (Associate Professor)
Hakimeh Mohammadhosseini (PhD Student)

DTU Technical University of Denmark

Idelfonso Tafur Monroy (Professor & Group Leader)
Juan José Vegas Olmos (Associate Professor)
Simon Rommel (PhD Student)

225m Outdoor Wireless Transmission

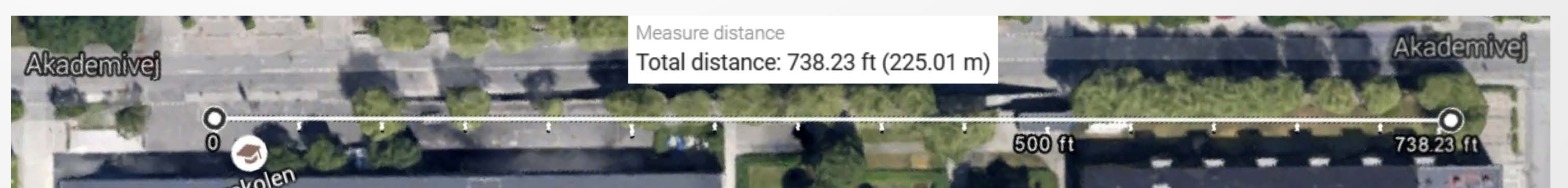


Figure 4. Outdoor transmission path on the DTU university campus

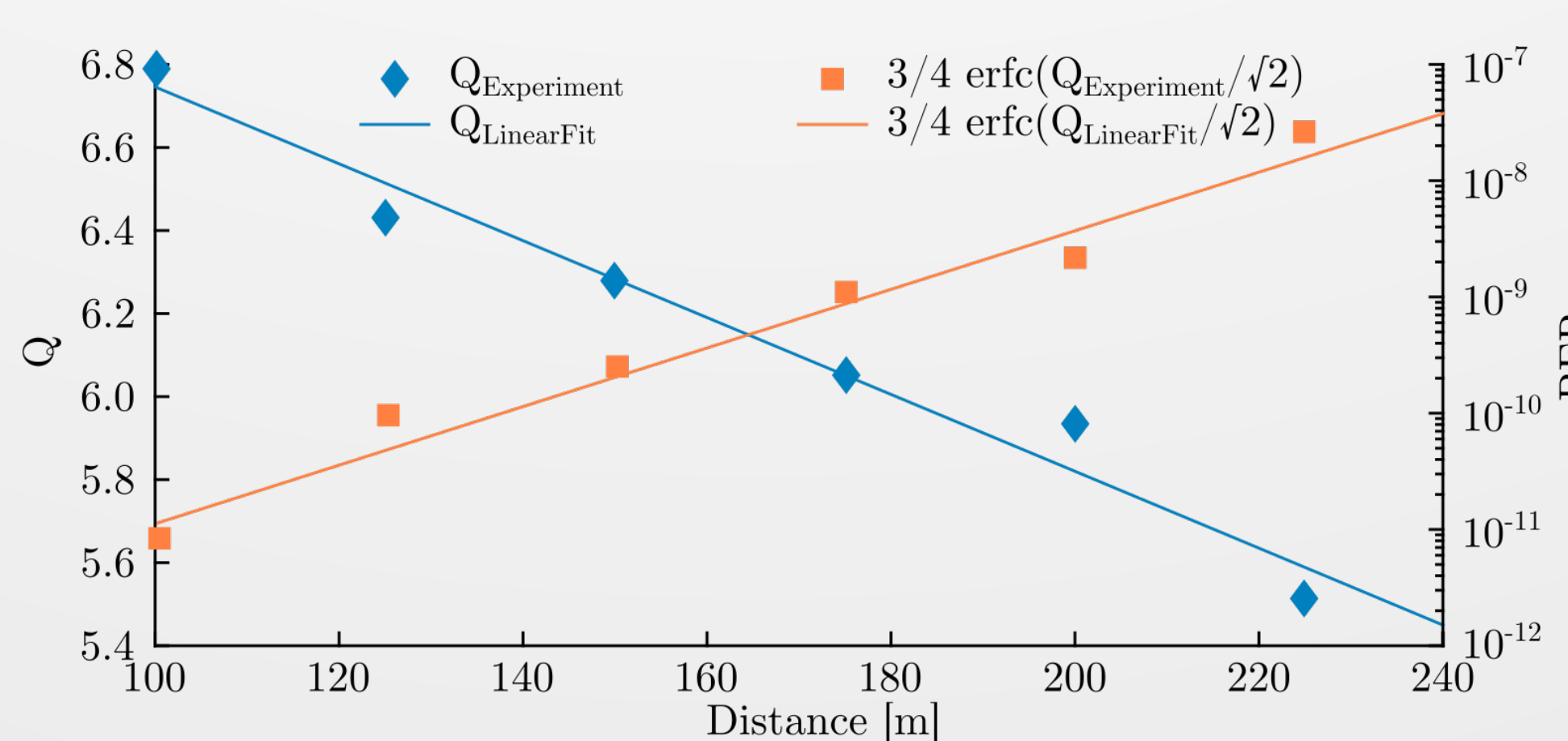


Figure 5. Q factor and BER over transmission distance

- ✓ BER < 10⁻⁷ at all distances
- ✓ linear relation between BER and distance

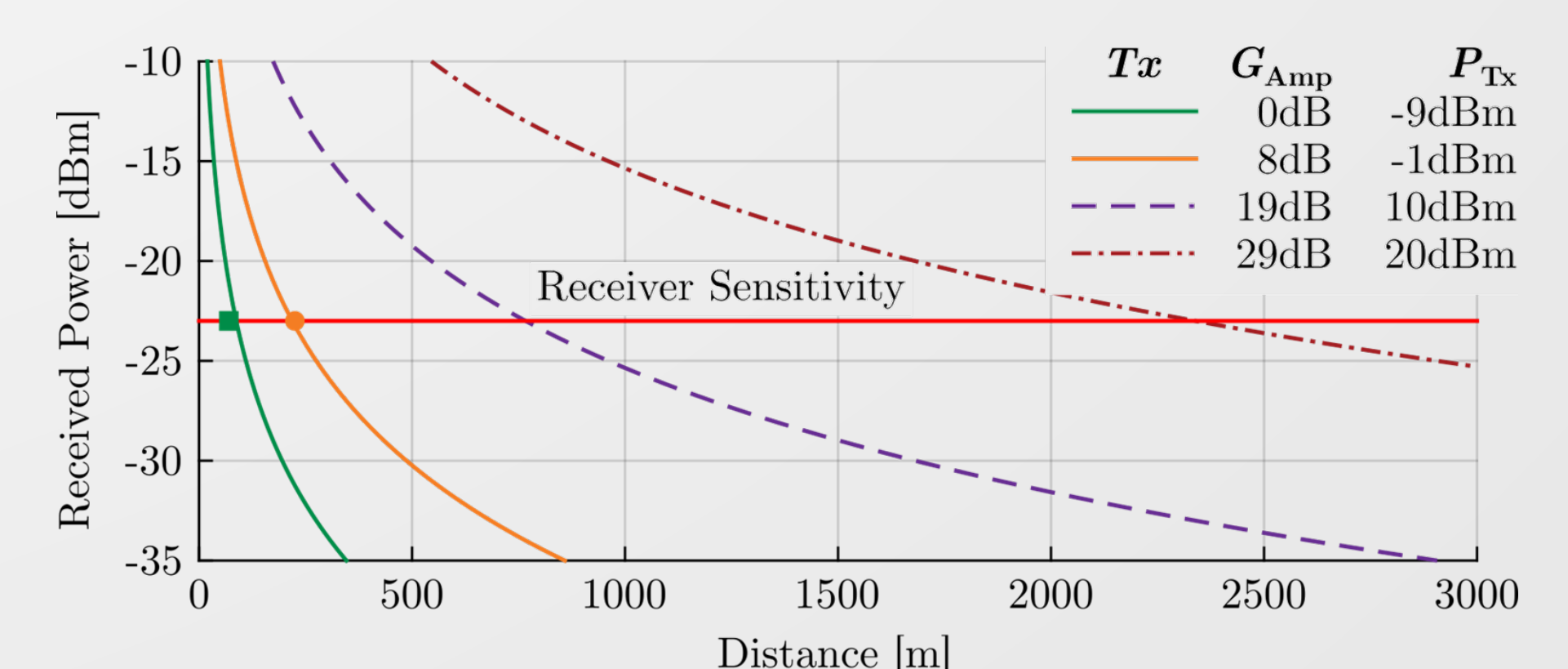


Figure 6. Calculated maximum wireless reach of the hybrid photonic wireless link

- ✓ up to 2340m wireless transmission with readily available RF equipment
- ✓ experiments agree well with Friis' model